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Flow Measurement for Structure Assessment in Richmond Irrigation District

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Prepared for:
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FLOW MEASUREMENT STRUCTURE ASSESSMENT
IN
RICHMOND IRRIGATION DISTRICT

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

Flow Measurement Structure Assessment

Report prepared for the
Richmond Irrigation District

by

Eric Leigh, Milton Henry, and Guy Fipps[1]
June 2, 2003

Summary
Extension Agricultural Engineering investigated the flume and flow measurement problem of Richmond Irrigation District. ***At normal operating conditions, the existing flume is over 90% submerged which makes it inaccurate for flow measurement***. An alternative is to calibrate the radial gate and use it for flow measurement. Accuracy is expected to be within 5 to 10% using this approach.

Materials and Methods
Milton Henry visited the site on April 11, 2003, met with Chad Elms, manager of the district, and provided preliminary assessment notes. The pump was not operating at this time, and a second visit was scheduled in order to observe the flume under normal conditions. Milton noted that no staff gages existed at the site.

Figure 1: 10 foot Parshall flume and water level of flow measurement on May 16, 2003.

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On April 25, Eric Leigh visited the site and met with Chad Elms. During this visit, the dimensions and elevations of the flume were surveyed using a *GPS 5700 Total Station*. A set of staff gages was provided to the district. A return visit was scheduled to measure the flow through the structure since the canal was temporarily shutdown.

On the return visit (May 16, 2003), Eric met with Mike Phillips, Manager of the pumping station that supplies the water to the irrigation district. Mike and his crew provided assistance in collecting data during this visit. Work conducted included:

1) upstream and downstream staff gage readings,
2) flow measurements,
3) height of the side walls at staff gage locations,
4) radial gate opening position, and
5) upstream water depth of radial gate and wall height.

Flows were measured using a *Price Type AA current meter*, *model 1220* with conventional round wading rod, and a *CMD 9000 Diameter* by *Scientific Instruments, Inc.* Following USGS recommended procedures; the Two-Point Depth method was employed in measuring mean velocities in a vertical line

<u>Survey Results</u>

The approach to the flume (side walls of the rectangular concrete section) and the Parshall flume are level. The water levels observed during this visit are shown in the schematic below (Figure 2).

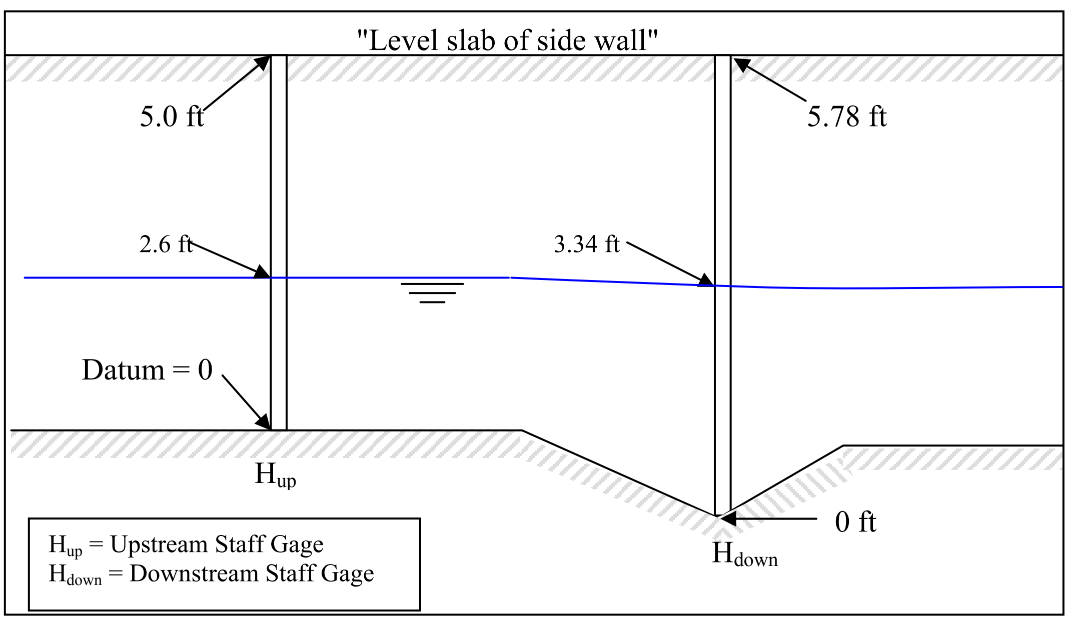

Figure 2: Parshall flume profile and staff gage locations with measurements.

Flow Measurement and Flume Observations

The following are our notes and observations:

(1) On May 16, the flume was submerged. Submergence is calculated from the difference in head at specific upstream and downstream locations within the flume (Figure 2). The calculations are as follows:

H_{up} (upstream staff gage) = 2.6 ft (2.4 ft below the top)
H_{down} (downstream staff gage) = 3.34 ft (2.44 ft below the top)

H (head): $H_{up} – (H_{down} – 0.78)$
Submergence: $H_{down} – 0.78 / H_{up}$

This gives a submergence 0.984 (98 percent).

(2) Mike Phillips noted that the flow on this day (H_{up} = 2.6 ft) was below average, and that normal flows usually corresponded to a depth of 4 - 4.5 ft.

(3) The flow rate measured was 83.87 cfs (Table 1). Table 2 provides details on the measurements and data collected.

Table 1: Canal attributes and flow calculated using the USGS midsection method from velocity meter measurements.

	Width (ft)	Depth Measured (ft)	Measured Area (ft²)	Avg. Velocity (FPS)	Total Discharge		Head*
					CFS	GPM	
District Irrigation Channel	16	2.6	41.6	2.016	83.87	37639	27.96

* corresponding head based on the relationship 1 head = 3 CFS

(4) The calculated flow rate using the flume was 115.64 cfs, using the following equation:

$$Q = 39.38 (H_{up})^{160} – 66 = 115.64 \text{ cfs}$$

(5) ***The difference between the measured flow rate (83.87 cfs) and the flow rate calculated from flume measurements (115.64 cfs) is 31.77 cfs or 27%.***

(6) ***Such large errors are expected from flumes with greater than 90% submergence.***

Radial Gate Flow Measurement

Gates can be calibrated and used for flow measurements. The accuracy of using gates varies, but can be within 10%. Figure 3 shows a diagram of the upstream radial gate and head measurement locations.

From the current-meter measurements, a *coefficient of discharge* was computed for the flow conditions on that day. ***Note, that we only measured flows for a single gate opening. We recommend that complete calibration of the radial gate be performed and a discharge curve be developed.***

Flow rates can then be calculated using the following equation:

$$Q=C_d G_o B\sqrt{2_g}H$$

where:

Q	=	discharge (cfs)	83.87	Calculated (see table)
C_d	=	coefficient of discharge	0.917	Calculated
G_o	=	vertical gate opening (ft)	1.3	Measured
B	=	gate width (ft)	16	Measured
G	=	gravitational constant	32.2	(USBR)
H_1	=	upstream depth (ft)	2.9	Measured
H_2	=	downstream depth (ft)	2.6	Measured
H	=	$H_1 - H_2$ (Head)	0.3	Calculated

***Figure 3 corresponds to the above calibration variables.

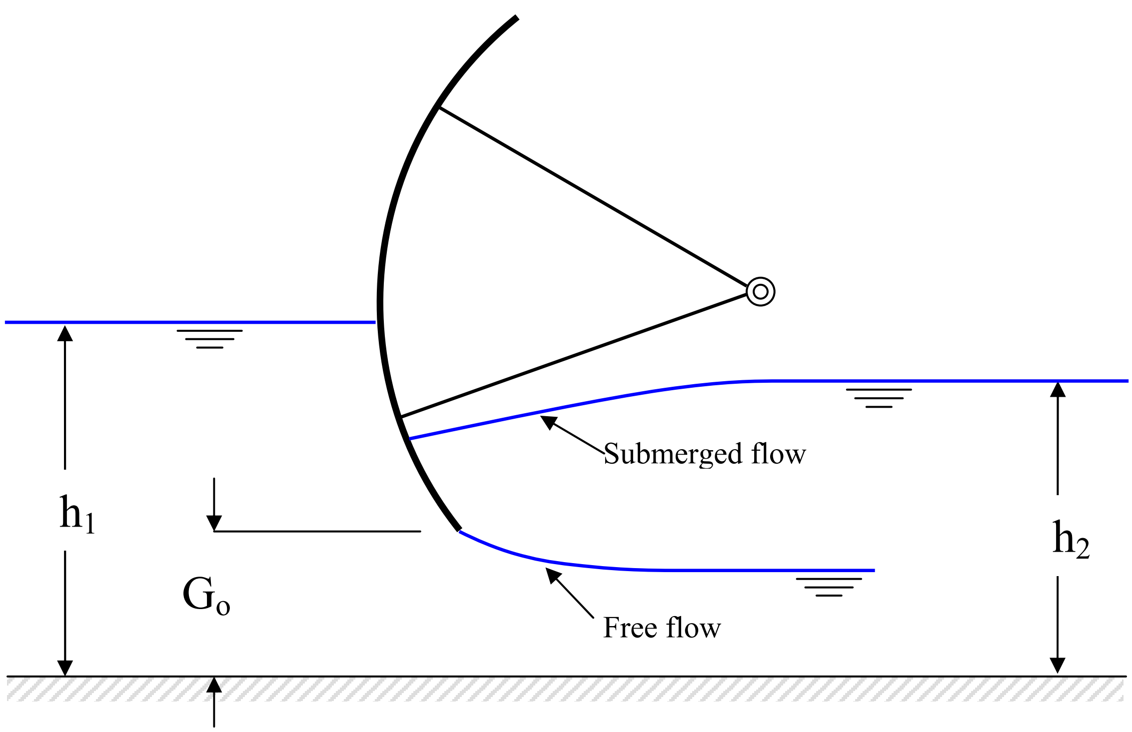

Figure 3: Diagram of Radial Gate showing calibration variables.

Figure 4: Shows above (figure 3) Radial Gate

Table 2: Current-meter field notes and computations using the midsection method.

Section	Dist. from initial point (in)	Width (ft)	Measuring Point (in)	Depth (ft)	Observation %	Observation Depth (ft) From bottom	Rev-olu-tions	Time in sec-onds	VELOCITY (FPS) At Point	VELOCITY (FPS) Mean Avg	Area (ft²)	Discharge (cfs)
1	12	1	6	2.6	.2	0.52	35	38.5	2.01	2.26	2.6	5.876
					.8	2.08	46	40.7	2.51			
2	24	1	18	2.6	.2	0.52	44	40.4	2.42	2.41	2.6	6.266
					.8	2.08	44	40.8	2.40			
3	36	1	30	2.6	.2	0.52	43	40.9	2.34	2.325	2.6	6.045
					.8	2.08	42	40.4	2.31			
4	48	1	42	2.6	.2	0.52	40	40.7	2.18	2.215	2.6	5.759
					.8	2.08	42	40.5	2.25			
5	60	1	54	2.6	.2	0.52	36	40.3	1.99	2.08	2.6	5.408
					.8	2.08	40	41	2.17			
6	72	1	66	2.6	.2	0.52	38	41	2.05	2.075	2.6	5.395
					.8	2.08	39	41	2.10			
7	84	1	78	2.6	.2	0.52	34	40.1	1.89	2.055	2.6	5.343
					.8	2.08	40	40	2.22			
8	96	1	90	2.6	.2	0.52	33	40.3	1.82	1.84	2.6	4.784
					.8	2.08	34	40.6	1.86			
9	108	1	102	2.6	.2	0.52	30	40.2	1.66	1.725	2.6	4.485
					.8	2.08	33	40.8	1.79			
10	120	1	114	2.6	.2	0.52	31	40.9	1.69	1.74	2.6	4.524
					.8	2.08	33	40.7	1.79			
11	132	1	126	2.6	.2	0.52	33	40.8	1.79	1.825	2.6	4.745
					.8	2.08	34	40.7	1.86			
12	144	1	138	2.6	.2	0.52	33	40.7	1.81	1.835	2.6	4.771
					.8	2.08	34	40.7	1.86			
13	156	1	150	2.6	.2	0.52	34	40.1	1.89	1.935	2.6	5.031
					.8	2.08	36	40.4	1.98			
14	168	1	162	2.6	.2	0.52	35	40.1	1.91	1.91	2.6	4.966
					.8	2.08	35	40.8	1.91			
15	180	1	174	2.6	.2	0.52	35	40.7	1.91	2.02	2.6	5.252
					.8	2.08	39	40.7	2.13			
16	192	1	186	2.6	.2	0.52	36	40.7	1.97	2.005	2.6	5.213
					.8	2.08	37	40	2.04			
									Avg. Velocity (fps)	2.016		
										Total Area (ft^2)	41.6	
		Top Width = 16ft									Total Discharge (cfs)	83.87
											GPM	37639.06
											HEAD	27.96

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