Difficulties of Irrigation Water Measurement in Iran and Recommendations for a Suitable Method

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- Accurate measurement of irrigation water is needed for:
- Uniform application of irrigation water (especially in arid and semiarid zones)
- Improvement of irrigation efficiencies
- Facilitating payment of irrigation water fee

In Iran because of water limitations, farmers prefer to divert as much water as possible to increase agricultural productions.

Since water is a valuable commodity, some farmers do everything (even play tricks) to increase their water delivery

Flow measuring devices have not been popular in irrigation projects in Iran

- **Parshall flumes have been occasionally used, but costs and structural problems have limited their usage.**
- **In a number of projects Nyerpic distributors have been used.**

Nyerpic distributor have been the cause of several problems for farmers and water managers

They are very sensitive to destruction for delivering irrigation water

Some Nyerpic distributers were substituted by slide gates

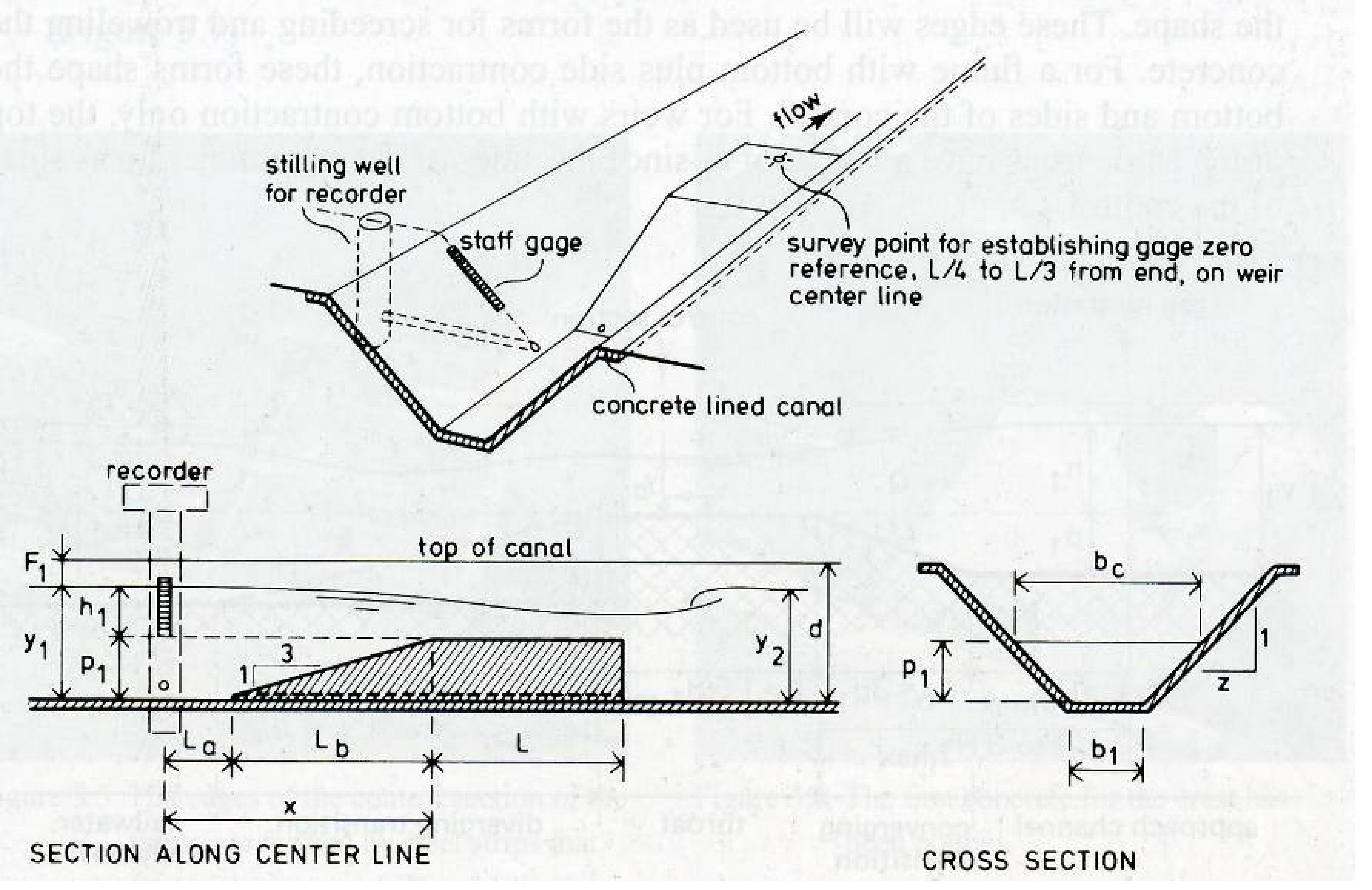
Unfortunately, farmers alter proper functioning of upstream structures used for controlling water level. The Amil regulator used for automatic control of upstream water level (Sarghanat channel network), is no longer functional due to placement of stones and metal pieces by the farmers.

In addition, these devices are not serviced regularly so, they can not control the water level in upstream channels.

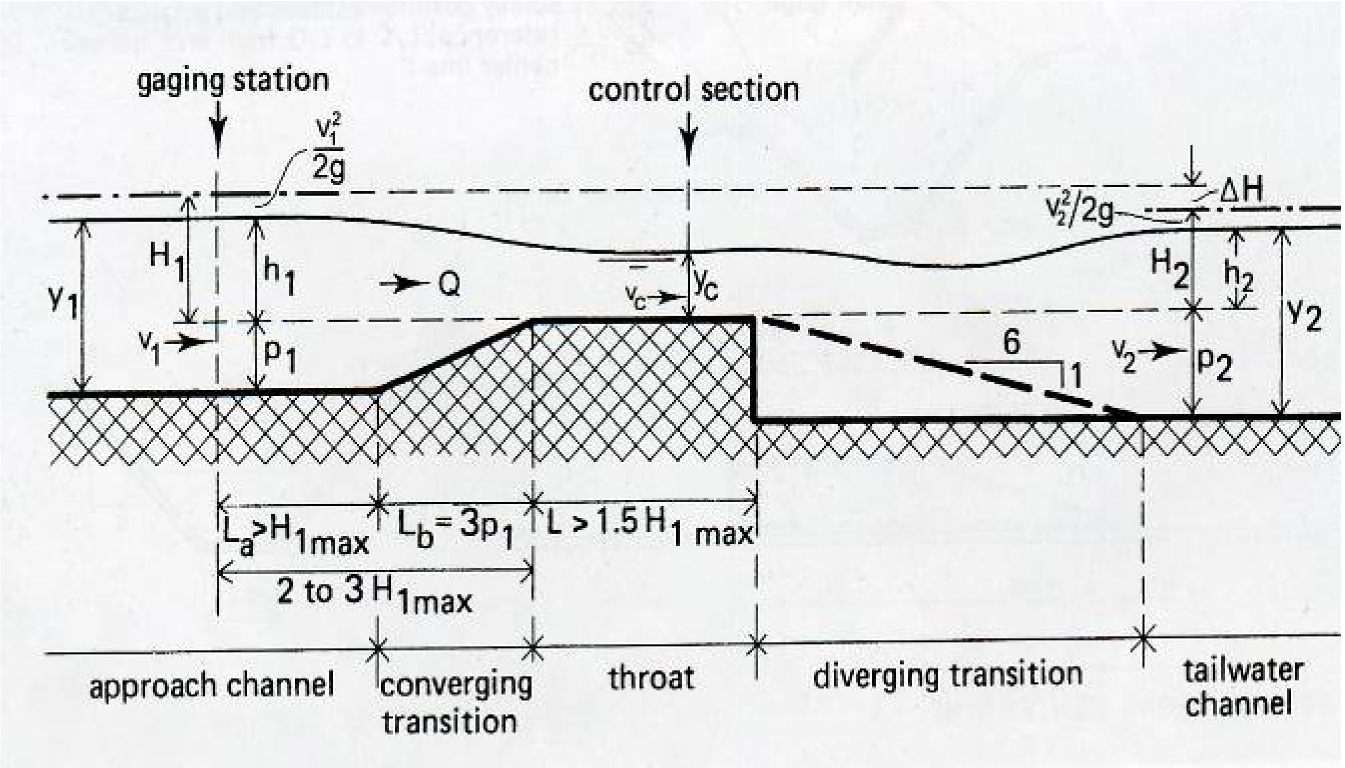
The Avio gates placed behind the orifice gates of dams are used favorably because only the water organization staff can control them and farmers can not destroy them.

Long-throated flumes, a viable solution to irrigation water measurement.

Long-throated flumes that measure channel discharges with minimum head loss are most economical, perform with high accuracy and do not need any calibration (Replogle, 1975; Bos et al., 1984; Clements, 2001).



In these flumes, throats are so long that streamlines are parallel In a short distance of throat section and energy equation can be applied through gaging and throat sections.



Doroodzan dam was built for storage of about 10^9 m^3 of Kor river in Fars province before 1971

About 80,000 ha of agricultural lands have been using irrigation water, delivered by networks of lined channels, in downstream area of Doroodzan dam since 1971. There is no water measuring structures in place, in tertiary and fourth order channels.

The inlet discharge of main channel has been measured by the reservoir gate opening. The flow in the secondary channels has been measured by

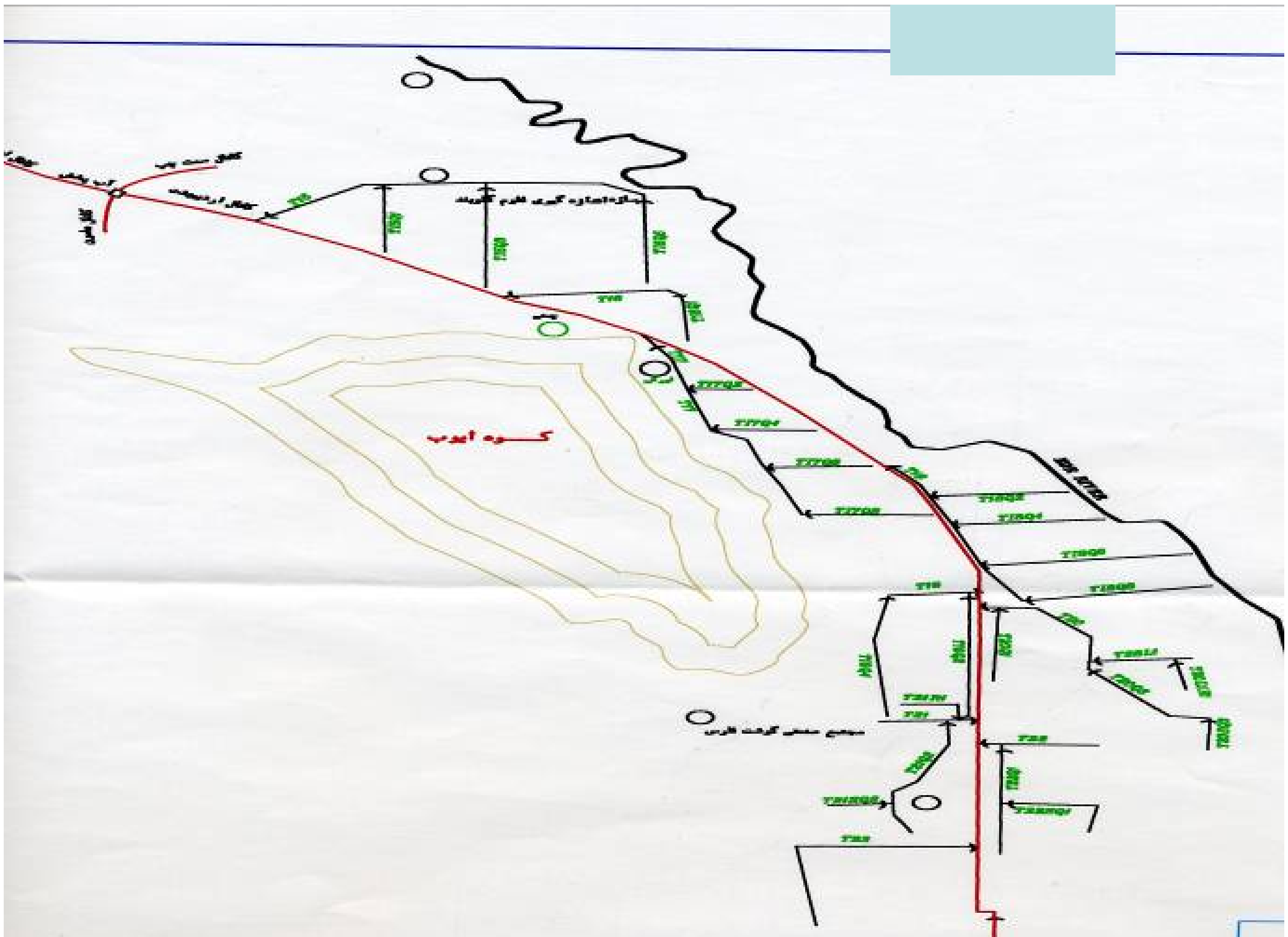
radial gate openings at the upstream end of each channel.

In some of the fourth-order channels, the CHO (Constant Head Orifices) structures have been built since 1971, but because of lack of measuring devices water discharge has not been measured in these channels.

View of incomplete CHO

Ten long-throated flumes were built successfully in Ordibehesht channel branches (the upstream end of tertiary channels) in 2004.

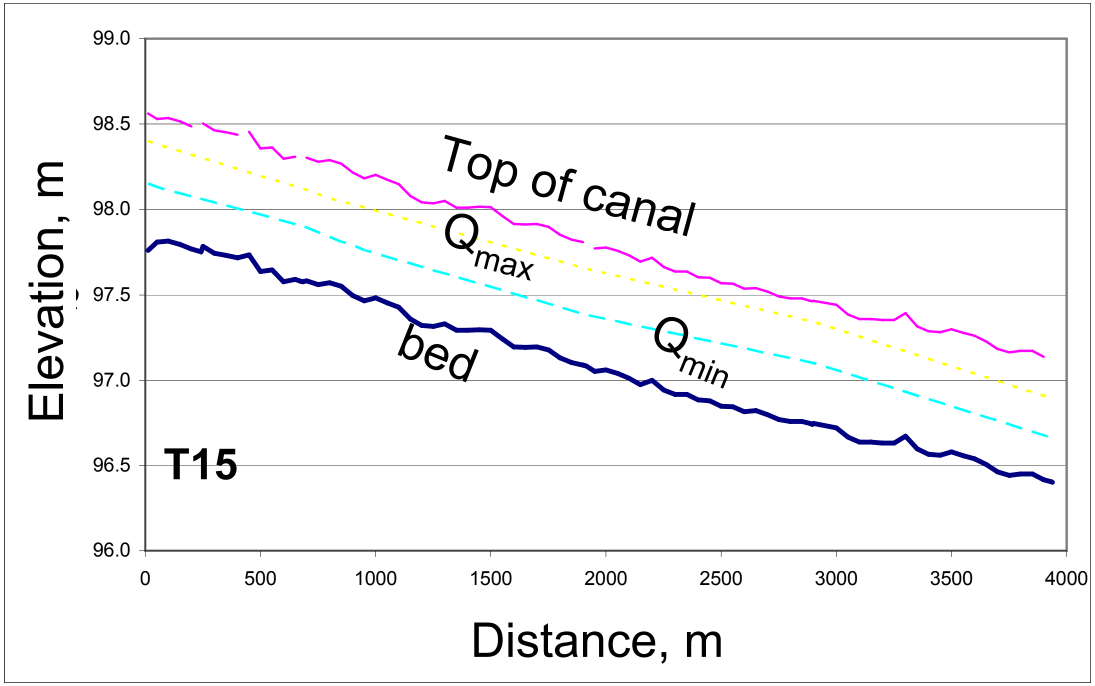
Rdibehesht channel is one of the secondary channels in the downstream area of Doroodzan dam.



The advantages of long-throated flumes in this project were

- Low economical costs
- Low required head loss
- No need for calibration in field conditions
- Simplified construction in existing channels
- **Resistant to vandalism**

The maximum existing channel depth was 0.97 m and the water level profiles in different channels were obtained by using the Hec-Ras software



max. watersuface EL at main canal 98.767

Evaluation of a three-year operation indicates that discharge measurements were done quite simply and favorably by farmers and staff of water delivery agency.

One of the built long-throated flumes

The down-side point in designing long-throated flumes is their dependency on computers (the WinFlume software), which is the main reason as to why these flumes have not been developed among some interest groups.

Development of closed-form equation for *h-Q*

- Knowing head-discharge (*h-Q*) relationship or their closed-form equation is very important in design of long-throated flumes. With this equation, like other measuring structures (i.e., weirs) designing the flumes will become much simpler.

Review of literature

For a proposed flume, the rating curve equation can be obtained by using the power equation (Clements et al., 2001).

The values of head-discharge (h-Q) data for a specified flume can be predicted by using

WinFlume software.

Where

$$Q = C(h)^n$$

$$Q = C(h+k)^n$$

- Q is discharge
- h is sill reference water surface elevation
- k and n are constant coefficients for a specified flume

Bos (1989) assumed the critical conditions in the throat sections and used a closed-form equation for obtaining rating curve in long-throated flumes as follows:

- $Q=C_d A_c(2g(H_1-y_c))^{0.5}$
- where
- H_1 is energy head at gaging station
- C_d is discharge coefficient
- g is acceleration due to gravity
- y_c and A_c are critical depth and wetted cross sectional area at throat section, respectively.
- In field conditions, it is not possible to measure the energy head H_1 directly, therefore, trial and error is required to relate the discharge to the upstream water level over the crest at gaging station.

- The discharge coefficient C_d is a function of ratio H_1/L (L is throat length) and is estimated from this Figure.

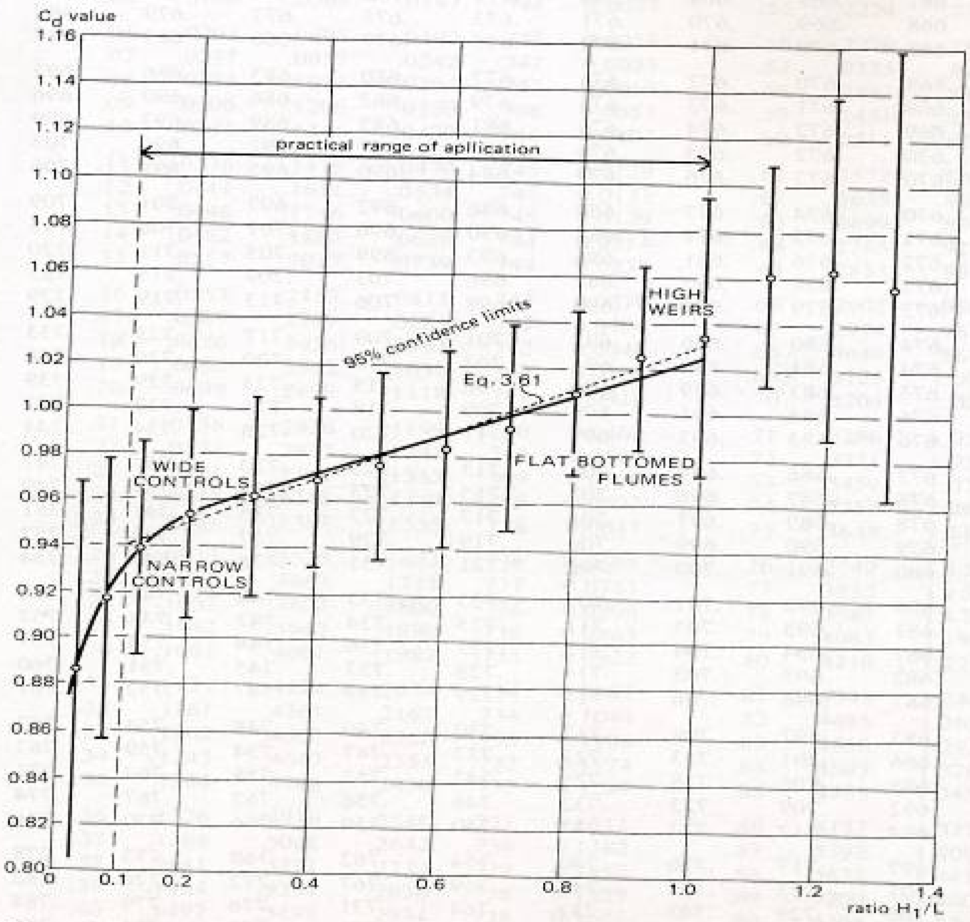


Figure 7.3 C_d values as a function of H_1/L for long-throated flumes of all shapes and sizes (Bos 1985)

Proposed Equation

- Because of critical condition at the control section, Froude number reach one and it can be shown as:

$$Q = \left(\frac{gA_c^{\,3}}{T_c}\right)^{0.5}$$

- where A_c and T_c are wetted cross sectional area (m^2) and water surface width (m) at control section, and g is acceleration due to gravity.

When the sill reference water surface elevation at gaging station (h_1) is greater than y_c, then :

$$Q = C_e \left(\frac{gA^{*3}}{T^*}\right)^{0.5}$$

- where A^* and T^* are throat wetted area and water surface width where water depth equals h_1, and C_e is a dimensionless coefficient and is less than one.

The relationship between the coefficient C_e is obtained by the parameter A^*/A_1 (A_1 is wetted cross sectional area at gaging station). obtained using winflume software results as follows:

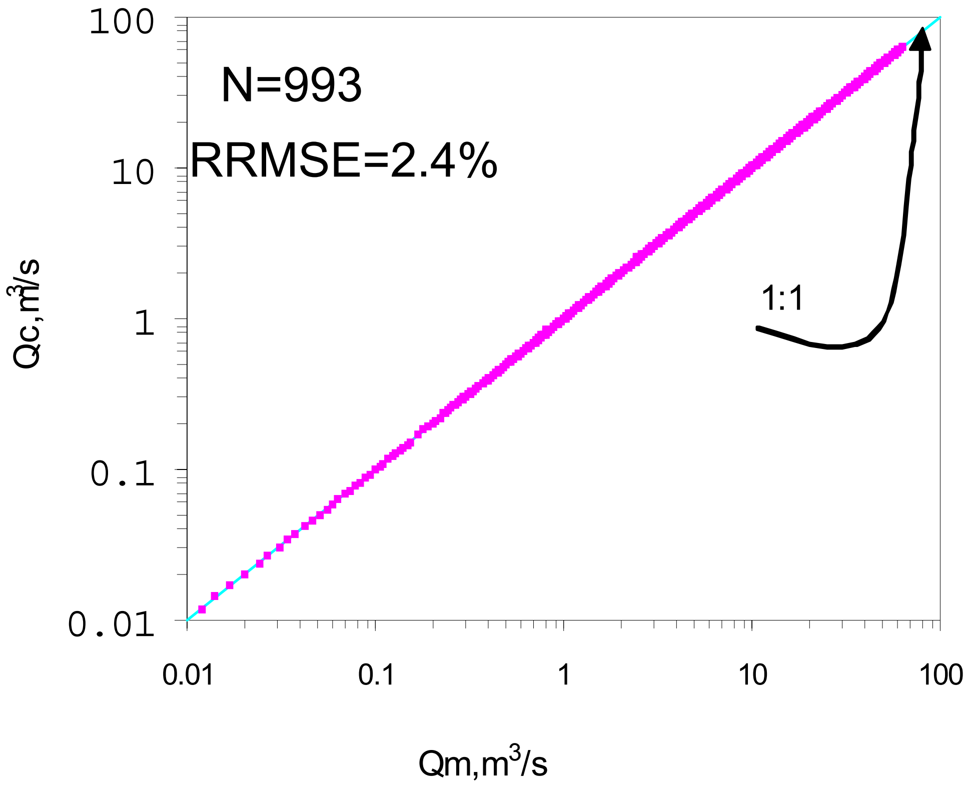
- $$C_e = 0.2615\left(\frac{A^*}{A_1}\right)^2 - 0.0269\left(\frac{A^*}{A_1}\right) + 0.5275$$

- $R^2 = 0.99$; $n = 1789$
- Channel side slope, $z_1=2$.
- Throat side slope, $z_2=2$.
- Discharges, Qp = 0.02-100 $m^3\ s^{-1}$.
- Channels bottom width, b_1= 0.3 - 5.0 m.
- Flume construction materials: smooth concrete with roughness height equal to 0.00015 m.

The value of *RRMSE* (Relative Root Mean Square Error)between the predicted discharges by WinFlume and proposed equation is equal to 2.4 % and this shows its accuracy.

- **For validation of the proposed Equation, these comparisons are made for channels and long-throated flume with side slopes (z) equal to 0.0, 1.0 and 1.5 and all of them have the value of *RRMSE* less than 2.5%.**

Comparison between predicted discharge values by WinFlume (*Qm*) and proposed Equation (*Qc*) for different channels and flume side slopes.



Conclusion

- **Construction of long-throated flumes appears to be the practical alternative for accurate measurement of discharge in irrigation channel networks in Iran.**
- **A simple closed-form equation for discharge measurements was proposed and compared favorably with those predicted by WinFlume software.**

Thanks for your attendance